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4

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27 **Abstract**

28 The aim was to compare the physical characteristics of under-18 academy
29 and schoolboy rugby union competition by position (forwards and backs).
30 Using a microsensor unit, match characteristics were recorded in 66 players.
31 Locomotor characteristics were assessed by maximum sprint speed (MSS)
32 and total, walking, jogging, striding and sprinting distances. The slow
33 component ($<2 \text{ m.s}^{-1}$) of PlayerLoadTM (PL_{slow}), which is the accumulated
34 accelerations from the three axes of movement, was analysed as a measure
35 of low-speed activity (e.g., rucking). A linear mixed-model was assessed
36 with magnitude-based inferences. Academy forwards and backs *almost*
37 *certainly* and *very likely* covered greater total distance than school forwards
38 and backs. Academy players from both positions were also *very likely* to
39 cover greater jogging distances. Academy backs were *very likely* to
40 accumulate greater PL_{slow} and the academy forwards a *likely* greater
41 sprinting distance than school players in their respective positions. The
42 MSS, total, walking and sprinting distances were greater in backs (*likely-*
43 *almost certainly*), while forwards accumulated greater PL_{slow} (*almost*
44 *certainly*) and jogging distance (*very likely*). The results suggest that
45 academy-standard rugby better prepares players to progress to senior
46 competition compared to schoolboy rugby.

47

48 **Keywords:** Player development; team sports; GPS; player load

49

50

51 **Introduction**

52 England has the greatest rates of participation in rugby union (Freitag,
53 Kirkwood, & Pollock, 2015). Age-grade players e.g., under-18 (U18) can
54 play concurrently in several standards including: amateur clubs, county
55 representative, schools, regional academies and international competitions.
56 During what is a key phase of athlete development, understanding the
57 physical match characteristics to which age-grade players are exposed at
58 different playing standards is important for physical preparation and long-
59 term player development (Hartwig, Naughton, & Searl, 2011; Tucker,
60 Raftery, & Verhagen, 2016).

61
62 Physical match characteristics of senior rugby union have been well
63 documented (Cahill, Lamb, Worsfold, Headey, & Murray, 2013; Quarrie,
64 Hopkins, Anthony, & Gill, 2013; Roberts, Trewartha, Higgitt, El-Abd, &
65 Stokes, 2008) and used to design match-specific protocols for training
66 purposes (Roberts, Stokes, Weston, & Trewartha, 2010). Characteristics
67 include the quantification of locomotor and contact exposures (Lindsay,
68 Draper, Lewis, Giese, & Gill, 2015; Quarrie et al. 2013). Practitioners
69 have often used these data to make inferences about age-grade players.
70 Understanding the multifaceted nature of age-grade rugby, that is, numerous
71 standards and age groups is complex and research has been limited. A recent
72 study using U20 international-standard players demonstrated that locomotor
73 characteristics such as total distance covered, are greater in backs than
74 forwards (6230 ± 800 vs. 5370 ± 830 m, effect size [ES] = 1.10) and are
75 also comparable to distances covered in senior rugby (Cunningham et al.,

2016; Reardon, Tobin, & Delahunt, 2015). However, because of the inclusion criteria in this study (>60 mins playing duration) and similar studies playing time, previous research has likely underestimated the physical characteristics of playing an entire match (Cahill et al., 2013; Read et al., 2017; Reardon et al., 2015). Furthermore, given that older age-grade players have substantially greater physical attributes such as stature, body mass and strength than younger age-grade players (U21 vs. U18; Darrall-Jones, Jones, & Till, 2015), it is necessary to investigate physical characteristics of U18 rugby so as to inform match-specific training. Previous research has also highlighted that the disparity in physical match-play characteristics between forwards and backs is less at U16 than U20 and thus warrants investigation in U18 players (Read et al. 2017).

Besides international competition, academy rugby is perceived by coaches to be the highest standard of rugby union in the U18 age group in England (England Rugby, 2010). Each academy has approximately three players each year graduate from the U18 academy to professional first team squads (England Rugby, 2014). Despite this, research thus far has examined only county representative and international standards in England (Cunningham et al., 2016; Read et al., 2017). There are 14 regional academies in England that are embedded in professional clubs and the U18 age group play six competitive matches a year against other academies from either the north or south regions of the country. Concurrently in this age group, players often play for their schools, yet the match characteristics to which players are exposed in these two playing standards are not yet established. In addition,

101 despite this playing structure and the recent interest in schoolboy rugby
102 (Carter, 2015; SportCIC, 2016; Tucker et al., 2016), assessments of
103 demands on U18 age-grade players are scant. Evaluation of U18 match-play
104 will identify demands of match play and evaluate current playing pathways
105 as progression to older age-grade and higher-standard rugby.

106

107 The primary aim of the current study was to compare physical
108 characteristics of English U18 rugby union match-play from two playing
109 standards i.e., regional academy vs. school, for forwards and backs. Second,
110 the study aimed to compare forwards and backs in the same playing
111 standard for academy and school rugby union match-play.

112

113 **Methods**

114 *Participants*

115 In total, 66 players were recruited from two playing standards (regional
116 academy and schools), providing 95 observations. See Table 1 for player
117 characteristics. An entire season of academy matches were assessed (six
118 matches), with a matched number of school games. All matches were played
119 from October to February. The players were recruited from one regional
120 academy hence, repeated observations of individual players were made. In
121 total, there were 45 observations from seven forwards (range = 1-4 matches,
122 21 observations) and 12 backs (range = 1-4 matches, 24 observations).
123 There were no repeated observations from the school players (25 forwards
124 and 25 backs, 50 observations) as the matches were assessed from six
125 schools. Three players represented both standards. The repeated

126 observations of players in the regional academy group and the inclusion of
127 the same players in the regional academy and school groups were accounted
128 for in the statistical analysis (Wilkinson & Akenhead, 2013). Ethics
129 approval was granted from Leeds Beckett University institutional ethics
130 committee.

131

132 ***** INSERT TABLE ONE NEAR HERE *****

133

134 *Procedures*

135 During matches, each player wore a microsensor unit (Optimeye S5,
136 Catapult Innovations, Melbourne, Australia) that contained a 10 Hz global
137 positioning system (GPS) and a tri-axial accelerometer, gyroscope and
138 magnetometer sampling at 100 Hz. The units were placed in a pocket in the
139 vest provided by the manufacturer and worn so it was situated between the
140 scapulae. All players were accustomed to wearing the units prior to the data
141 collection, during a training session. The mean \pm standard deviation (SD)
142 number of satellites connected during all data collection was 14.7 ± 0.8 ,
143 while the horizontal dilution of precision was 0.87 ± 0.15 .

144

145 The error of measurement (coefficient of variation; CV) for 10 Hz GPS
146 units is reported as 8.3, 4.3 and 3.1% for speeds between 1-2.9, 3-4.9 and 5-
147 8 m·s⁻¹, respectively, with the inter-unit reliability also established for the
148 same speeds as 5.3, 3.5 and 2.0% (Varley, Fairweather, & Aughey, 2012).
149 Additionally, Optimeye S5 GPS units have recently shown a *small* typical
150 error of the estimate (1.8%) with a radar gun for assessing maximum sprint

151 speed (MSS; Roe et al., 2016a). The accelerometer in the unit is also
152 reliable (CV for within: 0.9–1.1%; and between: 1.0–1.1%; Boyd, Ball, &
153 Aughey, 2011).

154

155 The data were downloaded using the manufacturer's software (Sprint 5.1.7,
156 Catapult Innovations, Melbourne, Australia) so only data from playing time
157 were included. All players played the entire game, which at the U18 age
158 grade is 35 min per half plus added time. Locomotor characteristics were
159 total distance covered, and split into pre-determined speed thresholds for
160 adolescent rugby union players: walking (0–1.94 m·s⁻¹), jogging (1.95–3.33
161 m·s⁻¹), striding (3.34–5.83 m·s⁻¹) and sprinting (>5.84 m·s⁻¹; Hartwig et al.,
162 2011). The MSS each player achieved during a match was also downloaded.
163 PlayerLoad™ slow (PL_{slow}) contains data for only low-speed activities (<2
164 m·s⁻¹) and is accumulated through accelerations recorded in the three
165 principal axes of movement. It was downloaded as a proxy measure for the
166 frequency and magnitude of low-speed exertions (e.g., scrummaging and
167 rucking) involved in rugby union (Roberts et al., 2008) that GPS or video
168 analysis cannot provide. The measure is related ($r = 0.79$) to collisions
169 during adolescent rugby union match-play (Roe, Halkier, Beggs, Till, &
170 Jones, 2016b).

171

172 *Statistical Analysis*

173 All data were log-transformed to reduce bias from non-uniformity error and
174 because of repeated measures in the sample, were analyzed using a linear
175 mixed-model (SPSS v.22, NY: IBM Corporation). Players 'group identity'

176 (i.e., academy or school and forwards or backs) was treated as fixed-effects
177 and random-effects were the ‘individual players’ and ‘matches’. Because of
178 the small sample size ($n = 3$) no additional analysis was completed on the
179 players that represented both standards. Magnitude-based inferences
180 identified practical importance via a spreadsheet (Hopkins, 2007). The
181 chances of match-play physical characteristics being less, similar or greater
182 than the smallest worthwhile change (SWC; 0.2 x between-subject standard
183 deviation) were calculated and assessed qualitatively as follows: 25-74.9%,
184 *possibly*; 75-94.9% *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly*
185 (Hopkins, Marshall, Batterham, & Hanin, 2009). Where the confidence
186 interval crossed both the upper and lower boundaries of the SWC, the
187 difference was reported as *unclear* (Batterham & Hopkins, 2006).
188 Descriptive data are reported as mean \pm SD, whereas differences between
189 groups are expressed as percentages with a 90% confidence limit.

190

191 **Results**

192 Differences between playing standards and positions for total distance, MSS
193 and PL_{slow} are shown in Figure 1, while the same analysis is displayed in
194 Figure 2 for walking, jogging, striding and sprinting distance.

195

196 *** INSERT FIGURE ONE NEAR HERE ***

197 *** INSERT FIGURE TWO NEAR HERE ***

198

199 **Discussion**

200 The purpose of this study was to compare physical characteristics of U18
201 rugby union match-play and hence, investigate the magnitude of difference
202 between two playing standards (academy and school) and positions
203 (forwards and backs). The main findings of the study were that academy
204 players covered greater total and jogging distances than schoolboy players.
205 Academy backs had greater PL_{slow} and the academy forwards did more
206 sprinting than school players in their respective positions. For positional
207 comparisons, backs had greater total distance, MSS, walking and sprinting
208 distance, while forwards had greater PL_{slow} and jogging distance. Overall
209 the results highlight that academy rugby is more physically demanding than
210 school rugby and players should be conditioned to meet the additional
211 demands during training for progression to senior rugby. Coaches should be
212 aware that academy rugby provides the greater physical challenge given that
213 players can play in both standards concurrently at U18.

214

215 Total distance was *almost certainly* and *very likely* greater in academy
216 forwards and backs than school players in the same position. Jogging
217 distance was also *very likely* greater in both academy positions and indicates
218 that some aspects of the locomotor characteristics are greater in academy
219 rugby. A positive association between fitness (maximal aerobic speed) and
220 distance covered by rugby players during match-play has been shown
221 (Swaby, Jones, & Comfort, 2016). Academy players' greater fitness could
222 be because of the greater intensity of their training (Phibbs et al., 2017),
223 although no data are available to directly support this in age-grade rugby
224 union. There are several *unclear* results of comparisons between the two

225 playing standards in both positions because of the large confidence
226 intervals. However despite this, all of the mean differences indicate the
227 academy-based measures are greater while there are no mean values that are
228 greater for the school players.

229

230 Notably, academy forwards showed a *likely* greater difference in sprinting
231 distance than school forwards while academy backs had a *very likely* greater
232 difference in PL_{slow} . The PL_{slow} and sprinting distance are typically key
233 measures for forwards and backs, respectively. However, PL_{slow} for backs
234 and sprinting distance for forwards differed between academy and school.
235 These findings suggest that academy players are prepared to a higher
236 physical standard. This reflects outcomes of a recent study that examined
237 training practices of these two groups (Phibbs et al., 2017). Phibbs et al.
238 (2017) showed that during academy training sessions players covered
239 greater total distance (4176 ± 433 vs. 2925 ± 467 m, $ES = 2.70$), had more
240 high-speed running (1270 ± 288 vs. 678 ± 179 m, $ES = 2.40$) and PL ($424 \pm$
241 56 vs. 270 ± 42 AU, $ES = 3.00$). Furthermore, academy players dedicate
242 twice the duration (13 vs. 27%) of their training time to resistance training
243 than school players (Palmer-Green et al., 2015). This is reflected in the
244 greater body mass of the academy players in this study and is likely to
245 influence the physicality of match-play. Playing styles of the teams were not
246 considered in this study and the impact these have on physical
247 characteristics during rugby union match-play is unknown.

248

249 Differences in MSS between the academies and schools for forwards and
250 backs remain unknown because of the *unclear* results. However, it should
251 be noted that MSS during a match is likely to be influenced by the number
252 of opportunities to achieve this such as linebreaks. Values in this study are
253 less than previously reported for academy players during testing (forwards:
254 7.0 ± 0.7 vs. 8.1 ± 0.4 , ES = 2.00; backs: 8.1 ± 0.4 vs. $8.6 \pm 0.4 \text{ m}\cdot\text{s}^{-1}$, ES =
255 1.25; Darrall-Jones, Jones, & Till, 2016). In addition, variability of
256 measures is greater in the school groups, which suggests the academy
257 players are homogeneous. However, the inclusion of six schools and the
258 variations in coaching and playing styles might also have influenced the
259 variability in the school groups. Future research should examine the
260 variability of physical performance during match-play in these groups to
261 identify smallest worthwhile change.

262

263 Results of the current study showed that forwards from the academy (5461
264 ± 360 m) and school (4881 ± 388 m) were *likely* and *very likely* to cover less
265 total distance than academy (5639 ± 368 m) and school backs (5260 ± 441
266 m). Distances covered by school players are substantially less than
267 previously reported for international U20 players (forwards: 5370 ± 830 , ES
268 = 0.98; backs: 6230 ± 800 m, ES = 1.94) and Pro 12 rugby players
269 (forwards: 5639 ± 762 , ES = 1.52; backs: 6172 ± 767 m, ES = 1.82)
270 (Cunningham et al., 2016; Reardon et al., 2015). Academy backs also have
271 less total distance than older age-grade players (Cunningham et al., 2016)
272 and one study of senior players (Reardon et al., 2015), whereas the forwards
273 are similar to data reported in these studies. This suggests less disparity in

274 locomotor characteristics between forwards and backs when players are
275 younger, which increases as players get older. This has also been shown in a
276 similar recent study (Read et al., 2017). This could be attributable to inferior
277 technical ability (e.g., catch and pass ability) at younger age groups and it is
278 hypothesised that this leads to fewer involvements from the backs and
279 explains the lack of disparity between forwards and backs in locomotor
280 characteristics. Furthermore, physical preparation of rugby players during
281 training could be more position-specific as age increases.

282

283 The distribution of distance into speed thresholds accentuated differences in
284 locomotor characteristics between forwards and backs. Backs were *likely*
285 and *very likely* to cover more walking distance, while also *likely* and *almost*
286 *certain* to complete more sprinting distance than forwards in the academy
287 and school groups, respectively. Conversely, forwards were *very likely* to
288 cover more jogging distance in both playing standards. The difference in
289 striding distance was *unclear* between academy players while it was
290 *possibly* greater only in school backs. These differences represent
291 comparable patterns from previous studies (Austin, Gabbett, & Jenkins,
292 2011; Quarrie et al., 2013) that have suggested searches for open space by
293 backs and the subsequent repositioning in the field explain these findings
294 (Cahill et al., 2013; Read et al., 2017). While players should experience all
295 speeds and train multiple energy systems, these data suggest that backs
296 should use a polarised method to replicate the characteristics of match play
297 by focusing on high speeds interspersed with low speeds, whereas forwards
298 should engage more in ‘middle ground’ speeds. Because of the use of

299 arbitrary speed thresholds, the greater sprinting distance is also likely to be
300 associated with the *very likely* and *almost certainly* higher MSS achieved by
301 the backs in academy and school groups, respectively.

302

303 Our findings are consistent with recent studies that showed greater low-
304 speed activity measured via PL_{slow} in forwards than backs, with *almost*
305 *certain* differences both for the academy and school (McLaren et al., 2016;
306 Read et al., 2017). The difference between forwards and backs is likely
307 because of more tackles (0.15 ± 0.08 vs. 0.11 ± 0.11 n.min⁻¹, ES = 0.42) and
308 rucks (0.33 ± 0.25 vs. 0.13 ± 0.09 n.min⁻¹, ES = 1.33), as well as the
309 addition of scrums (Lindsay et al., 2015). However, information on age-
310 grade players is scarce (Tucker et al., 2016). Despite the correlation between
311 PL_{slow} and collisions ($r = 0.79$), the measure will accumulate during any
312 activity <2 m.s⁻¹ and an algorithm specific to collisions in rugby union is
313 needed. In summary, differences in physical characteristics in U18 rugby
314 union match-play between forwards and backs means that practitioners no
315 longer have to make assumptions from senior data. Future research should
316 use larger sample sizes that would improve analyses of individual positions
317 or positional sub-categories (e.g., front row, second row, etc).

318

319 A limitation of this study is the small sample of matches and observations.
320 However, it includes one full season of matches from the academy league in
321 England. In addition, it is acknowledged that data from several academies
322 would improve representation of the characteristics and a combination or
323 comparison of academies and schools from the north and south of the

324 country would further enhance this. The concept of analysing match
325 performance from players competing in several playing standards
326 concurrently to assess if and why changes occur from a physical, technical
327 and tactical perspective warrants further investigation.

328

329 **Conclusion**

330 This study quantifies the physical characteristics of U18 rugby union match-
331 play and is the first investigation to compare regional academy and school
332 playing standards in age-grade rugby. These data highlight that academy
333 players experience greater match-play demands than school players and
334 should be conditioned to meet these demands. As players can play in both
335 standards concurrently, coaches should be aware of the impact on acute
336 fatigue and long-term player progression of rugby union players. Findings
337 from the locomotor and low-speed activity characteristics of forwards and
338 backs reaffirm the characteristics of these positional groups in age-grade
339 players and highlight the need for training to be position specific. Future
340 studies should investigate if players exhibit lower, similar or greater
341 technical performances (e.g., catch and pass ability, decision making) when
342 playing concurrently in different standards of age-grade rugby.

343

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471 **Figure 1.** Differences in total distance (A), maximum sprint speed (B) and
472 PlayerLoad™ slow (C) between playing standards and positions during
473 under-18 rugby union match-play. Differences are shown using magnitude
474 based inferences and percentage differences $\pm 90\%$ confidence limits. \uparrow =
475 Forwards are greater than backs or academy are greater than school. \downarrow =
476 Forwards are lower than backs or academy are lower than school.

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478 **Figure 2.** Differences in walking (A; $0-1.94 \text{ m}\cdot\text{s}^{-1}$), jogging (B; $1.95-3.33$
479 $\text{m}\cdot\text{s}^{-1}$), striding (C; $3.34-5.83 \text{ m}\cdot\text{s}^{-1}$) and sprinting (D; $>5.84 \text{ m}\cdot\text{s}^{-1}$) distance
480 (m) between playing standards and positions during under-18 rugby union
481 match-play. Differences are shown using magnitude based inferences and
482 percentage differences $\pm 90\%$ confidence limits. \uparrow = Forwards are greater
483 than backs or academy are greater than school. \downarrow = Forwards are lower than
484 backs or academy are lower than school.

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496 **Table 1.** Anthropometric characteristics for under-18 rugby union players in
 497 two playing standards and positions.

	Academy	School
Forwards		
Age (years)	17.4 ± 0.7	17.6 ± 0.7
Stature (cm)	188.2 ± 7.7	180.7 ± 7.4
Body mass (kg)	95.5 ± 7.5	90.2 ± 10.0
Backs		
Age (years)	18.0 ± 0.7	17.3 ± 0.6
Stature (cm)	180.7 ± 5.6	180.3 ± 6.4
Body mass (kg)	83.5 ± 9.6	77.4 ± 9.0

498 Data are presented as mean ± standard deviation.